HEALTH INFORMATION SYSTEMS

Plenary Presentations

Information for Malaria Control in Africa : Are We Ready?
    Don de Savigny

The MARA/ARMA Project – Theory and Practice.
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Summary Report

PLENARY PRESENTATIONS

Information For Malaria Control In Africa : Are We Ready?

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First, I wish to congratulate the organizers of the MIM Malaria Congress for putting the issue of Information and Communication so prominently on its agenda. Of the 30 plus sessions this week, at least 8 are fully or largely dedicated to health information systems and connectivity in support of malaria control. This is highly refreshing for a disease specific conference and I hope we can all make best advantage of this rare opportunity. I also want to thank the organizers for inviting me to tackle this topic and to be provocative. But from the outset, I must also warn you that I am not an information systems specialist. Like most here, I am a health professional working in Africa and I approach the subject from that perspective. And like most of us, whether coming from malaria research or malaria control, we must be interested in evidence and information on which to base the way forward and to monitor our progress. So I hope that what I have to say will have resonance with many of you.

In public health there are three things that we always complain of not having enough

- The first complaint is that there is never enough **time** . The clock is always ticking. Our most frequently used measures of health and disease are time based, be they time denominated epidemiologic rates or more recently, DALYs, Years of Life Lost, or Years Lived with Disability. For those focussed on malaria, even if we take the lower estimates of malaria mortality in Africa such as those in Murray and Lopez' Global Burden of Disease Analysis, or Bob Snow's more recent estimates of malaria mortality in the current issue of Parasitology Today, still over 10,000 Africans, mainly children and pregnant women, will die due to malaria during the 4 days of this MIM Conference. Time will always be against us.

- The second complaint is that there are never enough **resources** . The magnitude of the burden of disease in the world everywhere, but especially Africa, always outstrips available resources to respond adequately. Resources are always finite and constrained. Choices must be made. But more and more, these choices are being made on the basis of evidence and information rather than in the past where priorities have been set largely on the basis of common sense, albeit often poorly informed common sense, tempered by inertia, by last year's budget, by last year's epidemic, by donor paradigms, by special interest groups, by politics, and by funding opportunities rather than program needs. When resources are inadequate, allocation decisions must be supported by information and evidence.

- The third complaint is that we never have enough **information** . At least the information we need. And this is the issue that I have been asked to deal with during this half hour.

Of these three deficiencies: time; resources; and information, time will always be against us; and resources will always be constrained, but information could be different. We are on an exciting threshold. The ease and pace at which we can capture, store, manipulate, and communicate information is accelerating at a phenomenal rate. Unlike the costs of new anti-malarial drugs (and just about everything else in life), the real costs of managing and communicating information are actually dropping, and dropping fast. There are few things that have decreased in price as steadily and dramatically as the cost of storing a megabyte of information on our desktop. This has dropped about 50% per year, every year, over the past 15 years. On the information sharing front, at least for the research side of the malaria battle, e-mail can now reach field research settings such as Navrongo, Ifakara, Kilifi and many others. Several Ministries of Health in Africa already maintain their own Web Sites. For some of us there is already information overload. But is it the information we need to do the job at hand? To roll back malaria?

So, I am not going to talk about the many, still under-exploited opportunities that Information Technologies bring us. Instead, I would like to focus on the information itself, the actual sources of information for decision making.

This Conference bears witness to the fact that there is now a high level of political will to deal with malaria at the international level. We have MIM. We have Roll Back Malaria. We have the African Initiative for Malaria. We have a growing number of African networks against malaria (MARA/ARMA, EANMAT, INDEPTH to name a few). But we still do not have the necessary political will to Roll Back Malaria at the National, District, and Community levels in much of Africa.

What are the information needs to turn that corner? To mount a societal response to malaria proportional to the magnitude of the problem. What information is available? Is it what we need? What is missing? What are the new opportunities for information relevant to malaria control on the near horizon?

I will try to tackle this in two parts: the first focussing on what data sources we have now for evidence-based planning for malaria control; the second focussing on what information we need to measure our progress in reducing the burden of malaria.

1. Available Conventional Sources of Information for Malaria Control

There is not time to review all conventional sources of information for malaria control. So I would like to highlight only those that are available in the absence of a malaria control program. Where specific malaria control programs are already running well, their internal information systems are usually sufficient. But for most of Africa where integrated malaria control strategies are just taking off, information needs are more acute.

Conventional Sources of Information for Malaria Control

- **Routine Malaria Control Program Data**
  - **Vector Control**
  - **Active & Passive Case Finding**
- **Routine Health Services Data**
  - **HMIS**
  - **Standardized Hospital Reports**
- **Research**
  - **Survey Data**
    - **DHS**
    - **Community & Household Surveys**
    - **Health Facility Surveys**
    - **Rapid Appraisal and Needs Assessment Exercises**
  - **Intervention Trials**

1.1 Routine Health Services Data

1.1.1 HMIS

Let me start with the most commonly accessible information for the health system. This traditionally comes from the system's own health facilities. In the past this took the form of routine annual reports from health facilities and it was implicitly assumed to reflect the state of the health problems of the population. More recently, many countries have made efforts to systematize the collection and use of health facility data. They do this by applying health informatics to develop a Health Management Information System reaching down to the peripheral health facility level. The general purpose of such systems is to enhance quality of care, facilitate accountability, and assist cost containment. They usually do so by applying a hierarchy of:

a. Transaction Processing at the Facility and District levels, feeding into :
b. Management Information System at the Regional and National Level; followed by:
c. Decision Support back to District and Facility Level

Health Management Information Systems HMIS

- **HMIS applies Health Informatics to:**
  - **enhance quality of care**
  - **facilitate accountability**
  - **assist cost containment**
- **Through a cycle of:**
  - **Transaction processing at Facility and District Levels**
  - **Management Information System at Regional and National Levels**
  - **Decision Support back to District and Facility Level**

Unfortunately most of the energies of HMIS go into transaction processing, rather less into the Management Information System, and least into the Decision Support back to the periphery. We see volumes of forms filled at facility level logging attendances, diagnoses, prescriptions, follow-ups, and referrals. These transactions are fed up the line to District, regional and national levels where at each stage, they are aggregated and collapsed into summary statistics. Yet very little comes back to the Districts, and virtually nothing comes back to the thousands of health facilities who continue generating information daily. In addition, the HMIS data are often incomplete due to under-reporting from HMIS facilities, and non-reporting from private and traditional facilities.

But there is a more serious deficiency in HMIS data sources. Even if the HMIS cycle were to be fully functional, the utility of facility based data for estimating population health and monitoring progress is highly questionable. Such data are easily biased by the quality of services; the availability of drugs and supplies; the performance of health workers; the physical and social access of the population; the local mix of governmental, non-governmental,

Malaria at Facility Based HMIS National Statistics for Tanzania

- **MALARIA is:**
  - **Leading Case for < 5 admissions 49%**

Malaria at Facility Based HMIS for Morogoro, Tanzania

District Statistics

- **Malaria is:**
  - **Leading cause of health service attendance**
  - **30% of attendances (285,037 in 1996)**

traditional, and private health services; user fees and other consumer costs; and most importantly, the health seeking behaviours of households. But is this a problem for malaria data?

Health facility data in Africa often cite "30% of out-patient attendances are due to malaria". But given the chronic under-support of malaria control across Africa, such data are evidently of limited practical value and certainly have not provided sufficient lobbying clout for Program Managers to set priorities or compete for resources, either at the National or local levels.

Despite malaria's dominance in the HMIS statistics, the District Health Plan priorities in this illustration failed to mention malaria, although they did specify resources for 11 other diseases including dental caries and hepatitis B. The District response to malaria defaulted passively to the anti-malarial content of the Essential Drug Kit, which amounted to only 5% of the intervention budget of the District. I suspect the same is true across most Districts of Africa, at least those fortunate enough to have an essential drug program.
And as for monitoring change in health status, can we really use facility based statistics? How do we interpret an increase in attendance? Is it due to improved quality and utilization of services, or due to an increase in community disease burden.

1.1.2 Standardized Hospital Record Reports

Another source of data is Standardized Hospital Reports. For severe and complicated malaria, hospital admission data may be better than routine peripheral HMIS data. Certainly changes in hospitalisation over time, numbers of blood transfusions conducted, and case-fatality rates should indicate changes in severe disease patterns in a community. Age-patterns of severe disease may provide insights into locally acquired immunity patterns. Seasonal patterns of severe disease can indicate opportune times for intervention. These data are available, although subject to some degree to the same biases as routine health service data. But there are few examples of the routine use of hospital data for planning and designing interventions. Perhaps standardized reporting from sentinel hospitals could go far to supplementing an HMIS with more relevant burden of disease information.

On the whole, it is very difficult to determine the costs of a comprehensive, system wide, HMIS, just as it is difficult to determine the benefits. However the costs are substantial because large numbers of facilities and event transactions are involved, and the benefits, at least for understanding the community impact and dynamics of malaria and other diseases, are marginal. Could some of the effort and cost of generating facility data every where be re-directed to collecting more relevant, higher quality data in sentinel sites to be shared appropriately? One idea might be to strip down HMIS only to indicators required to manage that facility efficiently and re-allocate the freed resources to something else. I will come back to what that something else could be later.

In any case, much work is required to examine the real value of HMIS data for District-level planning and impact assessment.

1.2 Research Data

1.2.1 Survey Data

Demographic and Health Surveys in Africa
29 Countries by 1999

The next commonly available source of information for malaria control falls under the research heading. These have traditionally come from cross sectional survey data, of which there are various sources.

National Demographic and Health Surveys (DHS)

National demographic and health surveys are now conducted every two years in 29 countries in Africa. These are routinely conducted on large nationally representative samples. For example, the last DHS survey in Tanzania involved 8,000 women. However samples are usually too small to allow sub-regional analysis. This is a limitation since most health reforms are decentralizing decision making to the District level at which the national DHS sample is too dilute. But the main limitation of the DHS data for the focus on mortality is that they employ indirect methods, and thus reflect the mortality pattern in the past, on average 3-5 years ago, but do not reflect contemporary burdens and impacts. Nevertheless, over time, the DHS can provide a broad picture of trends in infant and childhood mortality. But on the knowledge, attitudes and practice side, the DHS surveys offer abundant opportunities to conduct nationally and regionally representative polls of behaviours. DHS surveys often contain elaborate questions on family planning practices, respiratory diseases, diarrhoea management, etc. but have only superficial questions if any dealing with malaria, Recently, a more detailed DHS survey module on malaria is under-development. Should we, as a malaria community be influencing sampling and questions within national DHS survey instruments? For example, it would be relatively easy to develop questions which elucidate trends in bednet ownership, knowledge of net treatment benefits, source of anti-malarials, etc..

Cross Sectional Household Behaviour Surveys (impact surveys)

I now turn to non-DHS household surveys. HMIS style Information systems usually ignore health seeking behaviour and I will illustrate the consequences of that shortly. However, standardized, stratified, population proportional, cluster sample survey methods and instruments have recently been developed for the IMCI package which illuminate many important aspects of household health seeking behaviour in relation to childhood illnesses including malaria, and malaria preventive practices at home such as ITNs. These are best conducted as repeated cross-sectional surveys every few years in strategic locations where impact and trends need to be assessed. The cost is approximately 10,000 USD per survey and thus they are not for routine surveillance or HMIS.

Health Facility Multi-indicator (process surveys)

Based on the UNICEF surveys, similar cross-sectional surveys are being developed to document process change at health facility level for IMCI. These can be conducted in lock step with the Household Behaviour Surveys at marginal extra cost.

1.2.2 Intervention Trials

Still under the research heading, one of the most informative sources of data we have for malaria in Africa has come from demographic surveillance (DSS) mounted by the research community to test intervention efficacy for mortality reduction. Beyond providing objective evidence of intervention efficacy, these systems provide deep and unique sources of information on burden of disease. Just as intervention research in the form of removing the mythical Broad Street pump handle in London in the 1830's taught us much about the epidemiology of cholera, so too has the intervention research in the form of randomised field trials of insecticide treated nets in Africa in the 1990's taught us much about the epidemiology of malaria. One result has been that the direct and indirect burden of malaria was shown to be much higher than expected. Almost all prior estimates placed malaria at 10% of under five mortality, yet the ITNs prevented 20 - 30% and in some settings even more of the under five mortality. This has gone far to re-shape our appreciation of the importance of preventing malaria. However, well designed intervention trials of sufficient size to document mortality are few and far between and cannot be counted upon to contribute routinely to national information systems.

1.2.3 Rapid Needs Assessment Exercises

Finally under the research heading, there are the needs assessments and situation analyses for malaria control. These have tended to be quick, often ad hoc, in and out exercises which collate but rarely produce new information. However, given the paucity of reliable malaria data at the national, district and community levels, Roll Back Malaria is developing a tool kit for a complete needs assessment. This assessment can be conducted within the space of a few months to assemble systematically all the necessary information to determine the scope and needs for integrated malaria control. This tool is currently being piloted but is an innovation that may prove very useful to mobilize both the political will and resources at national and sub-national levels. Those interested in this can subscribe to an active list serve sharing the methodology.

So, summing up the conventional sources of information for malaria control, we find that all the approaches have important deficits. What we need to do is avoid the bias and low quality of facility based data; avoid the lack of District specificity and contemporary relevance of the DHS burden data; and avoid the patchiness and low coverage of survey data, research trial data, and rapid assessments.

2. Emerging Sources of Information for Malaria Control

So what new sources of information could provide timely data of sufficient coverage and quality to advocate for, plan and allocate malaria control resources and to monitor progress in averting the mortality and morbidity associated with malaria? Here I would like to highlight just two new areas in which international networks have emerged very recently.

2.1 Spatial and Environmental Information Systems.

The first of these can be collected under the heading of Spatial and Environmental Information Systems. These information systems include the use of Geographic Information Systems (GIS) to map populations at risk in relation to their health risks, their health services, and their health programs as exemplified by the work of Health Map at WHO.

There is also the work of MalSat, NASA, and MARA / ARMA and others to harness satellite remote sensing data and other climate data in the service of malaria epidemic prediction in the highlands and other areas of unstable malaria in Africa.

Finally, there is the malaria specific work of the MARA / ARMA collaboration which seeks to map malaria transmission risk down to 5 km resolution across all of Africa. It is also developing a continental, spatial database of all pertinent malaria indices on burden of malaria, transmission risk, entomology, drug and insecticide resistance, etc. As an example, here is one MARA risk map for Tanzania illustrating the kind of heterogeneity that exists, even at the sub-District level. We need to examine how the availability of such new perspectives on malaria will influence malaria advocacy, resources and programs at National and sub-national levels for malaria control. Since you will hearing more about MARA later in this session I will not go into further detail.

Emerging Sources of Information for Malaria Control

- **Spatial and Environmental Information Systems**
  - **Health Program and Population Mapping**
  - **Satellite Remote Sensing for Epidemic Forecasting**
  - **GIS Modeling and Malaria Risk Mapping**
- **Sentinel Demographic Surveillance Systems**
  - **Community based burden of disease and trends**

Instead I will focus on the second potentially emerging source of information for malaria control, the idea of sentinel demographic surveillance for mortality and other indicators.

2.2 Sentinel Surveillance Data

First, why mortality? According to DALY estimates, malaria is one of the first and largest components of Africa's burden of disease. 90% of the malaria DALY in Africa is contributed by premature mortality as Years of Life Lost, the YLL component. Only 10% of the malaria DALY is years lived with disability or YLDs. Even so, malaria is the fourth ranked cause of disability or YLD's in Africa, such is the magnitude of the problem. Interventions that prevent malaria mortality also prevent malaria morbidity. Indeed Christian Lengeler's Cochrane meta-analysis of randomized controlled trials concludes that ITNs reduce overall child mortality by 18% and morbidity by 48%. Since 90% of the malaria DALY is premature mortality, we must measure mortality to assess properly the effectiveness of our strategies. The problem is that in Africa, vital event registration or cause of death data in any routine information system is rare. However, as we have seen, Demographic Surveillance Systems have been used to measure mortality efficacy in trials. Can the same DSS approach be used to influence priority setting and measure effectiveness in real life programming? Perhaps yes.

Here is an example of a Tanzanian District which, in 1996 had a health facility within 5 km of 85% of its population, was allocating 5% of its budget to malaria, was treating over a quarter of a million malaria cases per year and thought it was on top of the malaria problem, at least according to its facility-based HMIS. Then a District Demographic Surveillance System (a DSS) was introduced through a DFID funded Morbidity and Mortality Project which revealed a completely new and disturbing picture of the real burden of disease as experienced by the community.

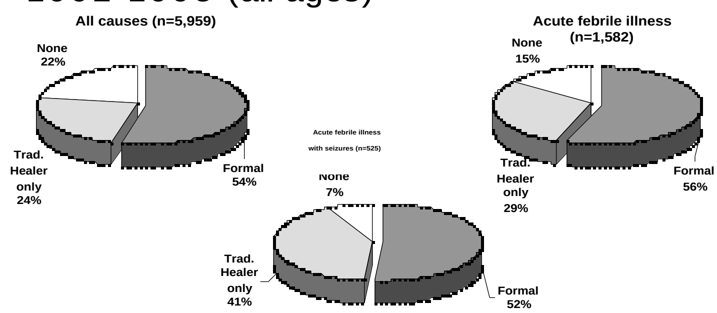
Community Based Burden of Disease Data - Insights from Sentinel Demographic Surveillance (DSS)

- ***Although 85% of households are within 5 km of a health facility…***
- **83% of all deaths occur at home**
- **84% of <5 deaths occur at home**
- **30% of total mortality burden is due to malaria**
- **45% of <5 mortality burden is due to malaria**
- **46% of deaths at home occur without prior health facility contact**
- **90% of deaths due to *acute febrile illness with seizure* occur at home**
  - ***Source: Tanzania Ministry of Health and AMMP Team, 1997.***

It showed that:
- 83% of all deaths occurred at home, including child deaths and were not counted in any HMIS
- 30 % of the total, and 45% of the child mortality burden was due to malaria

But more disturbingly, despite high facility attendance:
- 46% of all deaths, including malaria deaths, occurred without prior contact with a health facility
- 90% of child deaths due to acute febrile illness with seizure occurred at home.

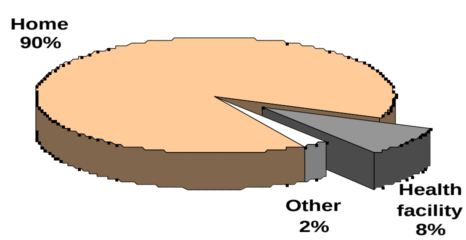
Contact with Formal Health Facilities in the Illness Leading to Death, Morogoro (R), 1992-1995 (all ages)



Based on: "The Policy Implications of Adult Morbidity & Mortality: End of Phase 1 Report" (1997) Tanzania Ministry of Health & AMMP Team, Dares Salaam.

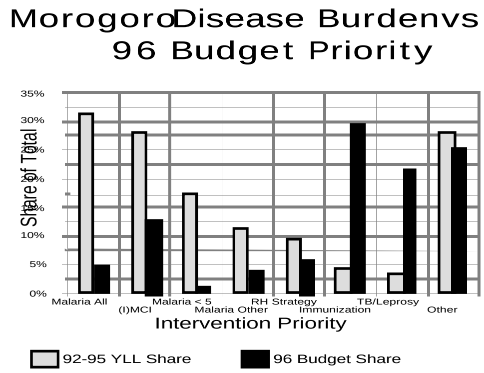
The District was shocked by 1) the degree of mortality outside the system, and 2) the degree of under-utilization of its health services for severe and complicated malaria (despite high coverage and high attendances for simple malaria). As one Ministry official put it, "*our facility based HMIS only showed us the nose of the hippo that was hidden beneath the water*".

Place of Death in Children Under 5 years from Acute Febrile Illness with Seizures Morogoro (R), 1992-1995

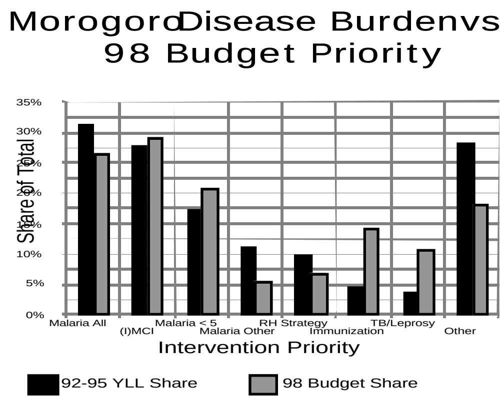


Based on: "The Policy Implications of Adult Morbidity & Mortality: End of Phase 1 Report" (1997) Tanzania Ministry of Health & AMMP Team, Dares Salaam.

What was the District response to this new appreciation from a community based DSS information system?



Unlike previously available HMIS attendance data which indicated ineffectively that malaria was a top priority, the policy and advocacy influence of these community based mortality statistics was swift. As you can see in these comparisons between 1996 and 1998, there was 5-fold increase in the share of resources directed to malaria control and a 20-fold increase in the share of resources for malaria control for children under 5. The District adopted and introduced IMCI in all its health facilities and now promotes social marketing of ITNs. Malaria is now, for the first time, given a prominence consistent with its disease burden in District Health Plans. The District DSS continues and will be used to document how these investments and strategies operate to reduce the burden of disease.



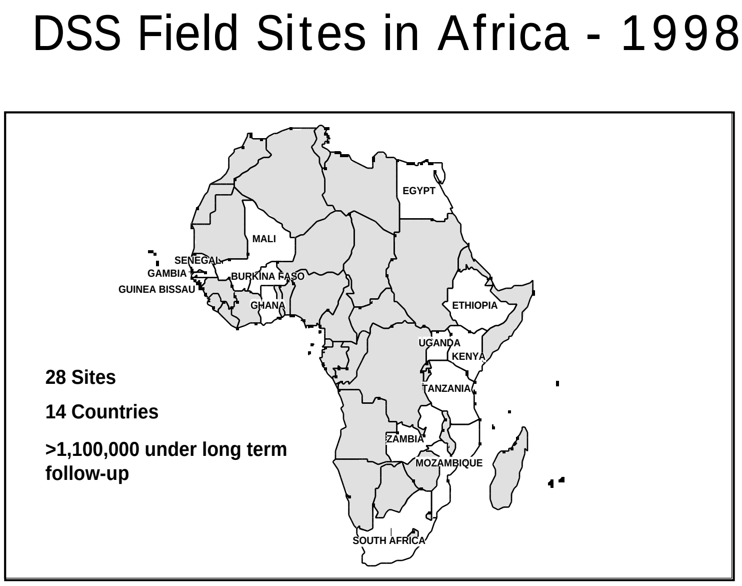
DSS: What is it?

- **Demographic Surveillance System**
  - **A geographically-defined population under continuous demographic monitoring with timely production of data on all births, deaths, and migrations (INDEPTH, 1998)**
- **How does it work?**
  - **enumeration of denominator population by repeated household visits at regular intervals**
  - **continuous reporting of numerator vital events by community key respondents**
  - **cause of death determined by verbal autopsy**
  - **rigorous supervisory, quality control, and data management systems**
  - **Sentinel DSS annual cost estimated at < $0.03 per capita**

So what is a Demographic Surveillance System and how much does it cost?

A typical DSS is simply a geographically-defined, population, usually in the order of 40 to 100,000 people in which a longitudinal surveillance system documents all births, deaths, and migrations. It does so by conducting an initial census followed by re-enumeration up-date rounds at frequent intervals, at least annually if not quarterly, to determine the denominator at risk, especially young children. At the same time, a parallel system of community key respondents continually identify the numerator vital events of births and deaths. All deaths are followed up by a surveillance system supervisor who conducts a verbal autopsy to ascertain the cause of death. DSS systems have rigorous supervisory, quality control and data management systems in order to link events in the numerator to the population in the denominator. A single DSS in a rural African sample population of 100,000 will document cause and prior health seeking behaviour in an average of about 5 deaths per day. Unfortunately many of these deaths will be due to malaria.

How much does all this cost? To run six such DSS systems in a large country like Tanzania and using a stratification to distribute annual DSS results to Districts represented by their sentinel will cost less than 3 US cents per capita per year with present methods. UNICEF is working on a variation of village registers for vital event registration that might lower the costs of DSS even further.



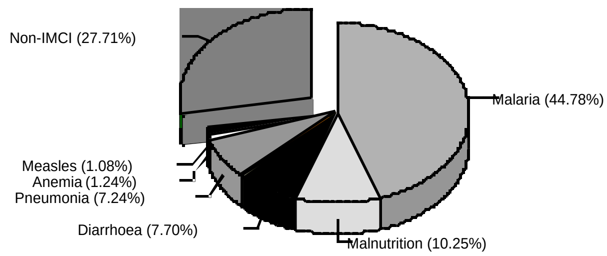
Because DSS provides quality data on household burdens of disease and a platform for a wide range of health, social, economic and behavioural analyses that can not be obtained in any other way, there has been an upsurge in DSS applications in recent years. In recognition of this, over 40 DSS field sites in the developing world have recently created a collaborative international network called INDEPTH. Its purpose is to harness the full potential of such sites, increase their technical efficiency, lower the costs of the methods, and maximize the policy influence of the information generated. In Africa, there are already 14 countries and over 1.1 million people under continuous follow-up by DSS in 28 field sites. In Tanzania, there are DSS systems running in 6 rural and 2 urban Districts. Tanzania will be the first country where the idea of sentinel DSS sites in a national HMIS will be tested. The INDEPTH network has established a Malaria Task Group led by the DSS site at Manhica, Mozambique, to assist the 27 African DSS field sites working in malarious areas.

But can DSS be used to monitor the effectiveness of strategies to roll back malaria?

Roll Back Malaria is not advocating vertical, malaria only approaches. It is talking about broad system wide changes and integration. Integrated Management of Childhood Illnesses (IMCI) is a case in point. The effectiveness of IMCI will be determined by a myriad of operational and behavioural features including coverage, utilization, provider and user compliance, diagnostic accuracy, efficacy of the anti-malarial drugs, referral, etc. If IMCI is effective, we should see a reduction in proportional IMCI preventable mortality, even if other causes such as HIV are to increase. Within the IMCI causes, the non-specificity of verbal autopsy for malaria is no longer an issue. Because the DSS documents all mortality, we are able to see shares of the whole. To have plausibility in attributing a decline in IMCI preventable mortality to IMCI effectiveness, we need to document process indicators relevant to IMCI by linking the IMCI household and health facility surveys into sites where the DSS sentinels operate. An INDEPTH Collaboration of four DSS sites, two with IMCI and two without IMCI is piloting this approach now in Tanzania.

Under 5 Burden of Disease - Morogoro

YLLs Addressable by IMCI



Source: Tanzania Ministry of Health, AMMP and TEHIP Teams, 1998

Conclusions

In conclusion. To sum all this up, we have important deficiencies in HMIS and survey style information sources. If there is one take home message I want to emphasize, it is that sentinel surveillance of all cause mortality at the household level through DSS may be our best chance 1) to obtain the least biased picture of current, initial malaria burdens and critical utilization behaviours; 2) to influence national policy and resources for integrated malaria control; 3) to document trends in disease burdens over time; and 4) to monitor effectiveness of Roll Back Malaria strategies.

But this still leaves the question of who should take ownership of health information for RBM - whether it be a DSS approach, or conventional HMIS, DHS etc. Most national information systems necessarily operate to support a wide sectoral requirement. Most of the interventions proposed to RBM at the national level will not be "malaria-specific" - for example, management of anaemia in pregnancy; management of childhood illnesses; improved drug-supply and rational prescribing, etc. Information, whether on process indicators or impact assessment, will be cross-cutting and demand ownership by, and integration into the wider health sector. Where then does the responsibility for malaria information lie and how can this be supported to meet the needs of RBM? RBM will be a component of improvements in health service delivery generally and therefore this raises the issue of who should drive Health Information Systems for Roll Back Malaria at country level.

As a closing perspective on this. We must accept that we will never have all the time, resources and information that we would like. But we may be able to re-allocate some of our existing time and some of our current resources to generating community based information on the burden of mortality and on health seeking behaviours specifically associated with this burden. These are two of the most important statistics which we must influence and monitor. Since most of the disease burden in Africa is under-pinned by malaria, we must push for and explore such re-allocations. Re-allocation of some resources from comprehensive, facility based MIS, to a sentinel, community based DSS system may emerge as our most cost-effective option.

As long as malaria tops the burden of disease in Africa, we, as the malaria control community, must not shy away from a role as "pathfinder" to strengthen Health Information Systems in Africa.

HIS for Malaria: the example of the MARA/ARMA network

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Uwe Deichman, Don de Savigny, Etienne Fondjo, Colleen Fraser, Eleanor Gouws, Imo Kleinschmidt, Pierre Lemardeley, Christian Lengeler, Dave le Sueur, Judy Omumbo, Bob Snow, Brian Sharp, Frank Tanser, Thomas Teuscher, Yéya Touré

It is an honour to be able to represent in this forum a network of scientists, who have made possible what most people deemed impossible, through their personal interest, dedication and contribution. MARA's achievements are the achievements of these individuals working together as a team towards a common goal. MARA is not an organization, it does not have a centre where things happen; it is a true network that is as strong as the people it consists of. MARA is a true partnership - not only between these individual scientists, but between different countries, different disciplines, different institutions, even of different funders.

You have now heard the Mapping Malaria Risk in Africa project being mentioned several times since Sunday evening, but Where does MARA come from? What does MARA do? Where is MARA now? Where is MARA going?

The origins of MARA

- The problem
We all know of the enormous problems malaria causes in Africa. We know of the renewed focus on malaria, and that many organizations are again dedicating their attention and resources to address the problem. We also know of the new tools that are available for controlling malaria today - such as insecticide treated nets, new drugs, improved formulations and packaging, rapid diagnostic tests, and still the hopes for an effective vaccine. But where to start? How to focus? What to do?

- The importance of information
Many factors influence the choice of how to control malaria in a particular region: malaria endemicity, vector species and behaviour, transmission seasonality, disease patterns, health services and more. Since none of these factors are distributed evenly across the continent, accurate, relevant and timely information on them is needed for malaria control to be planned and resources allocated properly. An increasing emphasis is being placed on evidence, so that the demand for an empirical approach to planning has grown.

- The value of maps
Maps offer an ideal way of displaying complex information in a way that is intuitively understandable and instructive. Everyone understands a map. They tell us not only what is happening, how much, but also where it is happening. A map is a powerful lobbying tool, which can be used to display to policy makers where the problem exists, where resources are employed, and possible discrepancies between the two. In South Africa for instance the spatial representation of malaria information has also led to more targeted malaria control, by pin pointing where malaria actually occurs, where control needs to be concentrated, and in fact, where control is not necessary.

The value of maps has been understood in the past, and malaria has been mapped in numerous countries, in some way or other. However, most efforts have been isolated and country-focussed, with malaria maps varying in their content, the way they were derived and their accuracy. While malaria and its control is increasingly being viewed as a continental rather than a national problem, a continental atlas of malaria, to analyse the big picture and target our efforts, does not exist.

- GIS in malaria control

Realizing the tremendous importance of space in the transmission of malaria, a geographical information system - or GIS - was started at the National Malaria Research Programme of the South African Medical Research Council in Durban in 1989 which focussed on mapping malaria risk in South Africa (1). Using GIS in health was a relatively new idea then, but it proved to be just the right thing to pinpoint exactly where the problem areas were and where to focus control efforts. The GIS group at the MRC developed considerable expertise in GIS and database management pertinent to malaria control, and this came to the attention of IDRC during a meeting on GIS for health and the environment held in Sri Lanka, 1994.

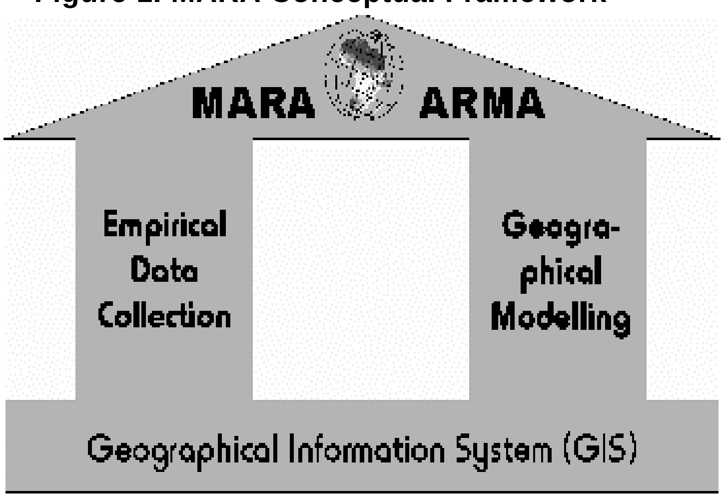
- The great plan

At the same time a need emerged to better understand the distribution of malaria transmission intensity, in the light of new control interventions and their short- and long-term effects (2). And as happens when great ideas come together and meet on common ground, the concept of MARA was born when Don de Savigny and Bob Snow proposed the development of a Pan-African collaborative network to map malaria risk, using the malaria GIS skills in South Africa as a platform. With support from the IDRC, Wellcome Trust and WHO/TDR, a series of workshops were held which developed the conceptual design of MARA (3).

What has MARA achieved?

From the start it was clear that MARA had to be built on two parallel and complementary approaches: a collection of existing empirical data and geographic modelling of malaria, both on a common GIS platform (Figure 1).

Figure 1. MARA Conceptual Framework



- Data collection

Large volumes of malaria surveys have been carried out by ministries, control programmes, research- and other organizations in the past. Unfortunately these data have been little used, poorly archived and risk being lost for future use. In the face of current needs for targeted and informed intervention, it is clear that all existing empirical data need to be brought together in one place, where they can be organized and accessed.

MARA started out with the bold intent of collating all possible published and unpublished data that could be located in sub-Saharan Africa. Since nobody knew what kind of format the data would be found in, a data collection system was designed that was flexible, but which at the same time standardized the collection process. Data are reported in a wide variety of different formats, but to be useful, have to be brought into one standard database. The proforma consists of separate sections that can be assembled as necessary, depending on the type and style of the reports (4).

- Database model

A relational database was then designed to accommodate the full complexity of all data relationships (Figure 2). The structure permits future growth, incorporation of new data entities, and a flexible means of combining data queries for analysis.

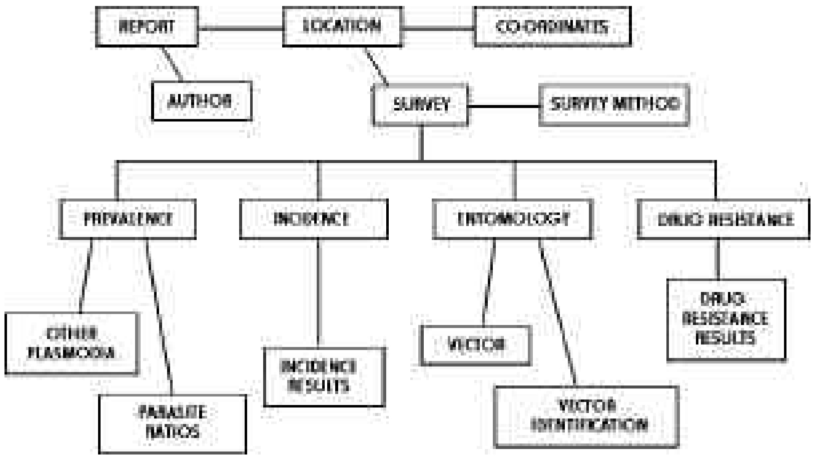
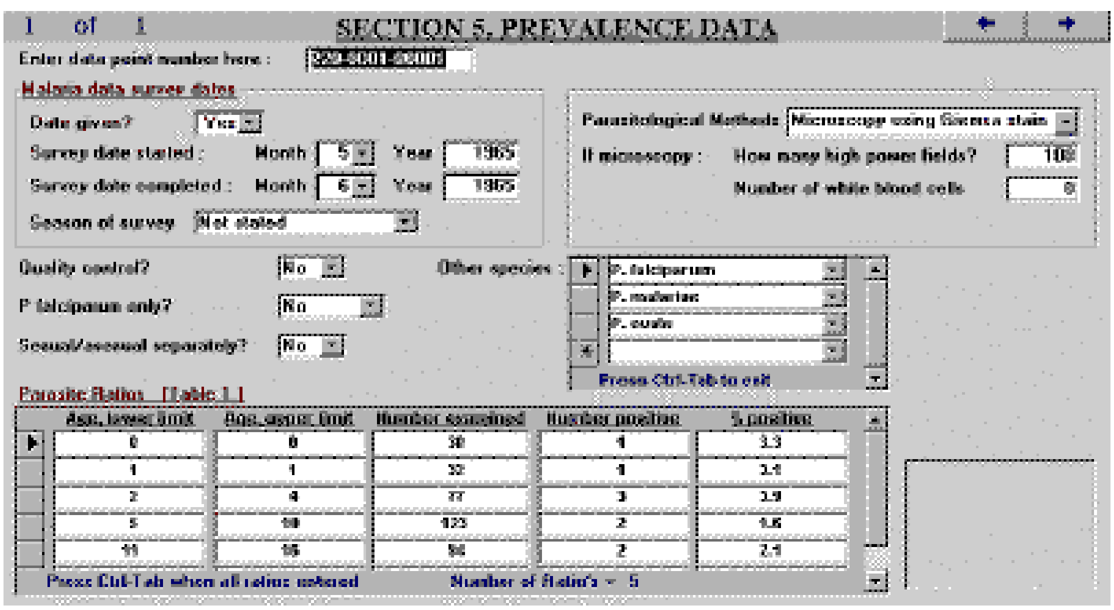


Figure 2. MARA database structure

- Data entry system

A stand-alone data entry software application, conforming exactly to the pro-forma, was created to make the data entry as easy as possible and to ensure standardisation (Figure 3).

Figure 3. Example of data entry screen



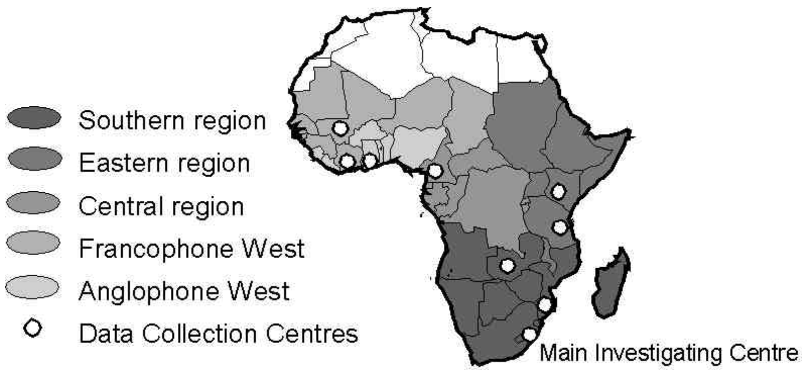
- Geo-referencing

Finally, to be able to integrate the data in a GIS, all surveys had to be "geo-referenced" (i.e their latitude and longitude determined). If the exact location of the survey site was not given in the report, it was obtained by searching for the place names on a topographical map, or by using digital maps and databases.

- Data collection regions and centres

For the data collection process Africa was divided into functional regions, with five regional centres and two sub-centres responsible for 5-7 countries in their region (Figure 4). The regional centres are located at existing institutions throughout the continent, each with a co-ordinator and a co-investigator, which make up the main MARA team. These people are established scientists who contribute part of their time to MARA activities.

Figure 4. MARA regions and centres



Many different strategies were applied to search for the data, including Medline and Embase searches of published literature, hand searches of relevant journals, and cross-referencing bibliographies. Further data was obtained by contacting researchers and authors known to have worked in a particular region. The data coordinators then began visiting all identified institutions likely to hold unpublished documents in the countries of their region. This included relevant ministries, universities and research institutions. Finally, international archives in Africa and Europe (WHO Geneva, Paris, Antwerpen, Lissabon) are being searched and all identified documents abstracted (5).

Figure 5. Data points collected by the end of 1998

- Data points collected to date

It is clear that such an ambitious task takes at least several years to complete, but if we look at the data that has been collected so far, it is remarkable how much has already been found. You can see that some countries are well covered, whereas others are sparse in data, still need to be visited or are presently inaccessible.

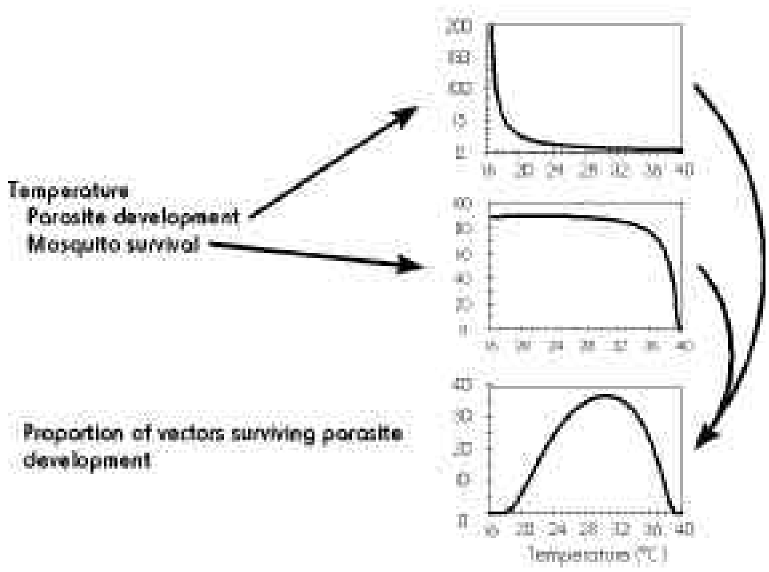
- Geographical modelling

This brings us to the second focus of MARAgeographical modelling. What is it and why do we need it? Prevalence data on their own are not enough to give us the whole picture of the status of malaria. Also, they do not cover the entire continent - as we saw, there are large data gaps, many of which will not be filled because data don’t exist there. modelling does is to fill the gaps and to answer some of the major questions that interest us.

- Modelling: questions and scales

What are some of these questions? The kind of questions we are interested in is where does malaria exist (distribution), how intense is the transmission (endemicity), when and for how long is malaria transmitted (seasonality) and what are the factors that cause these differences? These questions can then be addressed at different scales: we can look at the large, continental picture, we can focus on large regions with imilar ecologies or climates, or we can focus on the country or a group of neighbouring countries.

Figure 6. The effect of temperature on parasite development



-The main limiting factors of malaria

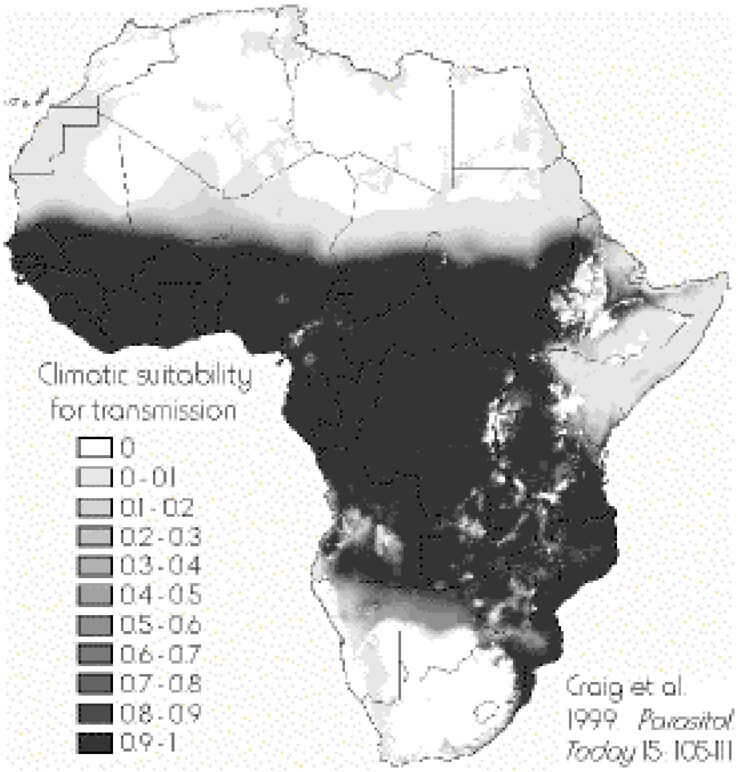
Malaria is an environmental disease that is strongly affected by the environment. There are numerous factors that determine the particular malaria situation from one place to the next. However, the two major factors that limit the distribution of malaria are temperature and rainfall. Rainfall is the source for mosquito breeding sites and determines humidity, which affects vector survival. Temperature affects many parts of the transmission cycle, but its effect on the development of the parasite in the vector, and on vector survival are the most pronounced (Figure 6).

The proportion of mosquitoes surviving the parasite’s sexual development is the major component in determining whether or not transmission takes place (6).

- Malaria distribution and seasonality

At the continental level, two models have been developed. The first (7) defines the distribution of endemic malaria, based on the biological constraints placed on the parasite and the vector by temperature and rainfall, as outlined before. The particular temperature-rainfall combination is rated as either suitable or unsuitable for transmission in the average year (Figure 7). I say "in the average year" because the climate data we used are long-term climate data which give the average conditions over the previous 60 years.

Figure 7. Malaria distribution model



The model agrees well with what maps we have on malaria distribution, its benefit being that it was derived in the same way all over the continent, and that this process can be repeated, refined and tested.

The continental distribution model was the first product to come out of MARA and put us into a position to take a look at malaria in African highlands, within the HIMAL project. Because it is a numerical model, it can be mathematically combined with other models, such as a population distribution model, which allowed us to estimate the continental morbidity and mortality of malaria in a repeatable and empirical way (8). The work on the continental burden of disease will be discussed in more detail by Dr Nabarro.

The second continental model defines the duration of transmission in months, at the same time indicating the first and last month of the transmission season (9) (Figure 8). This information is obviously important to the choice and timing of interventions such as spraying of residual insecticides. Different interventions may be suited better under different situations of malaria seasonality.

Figure 8. Malaria seasonality model

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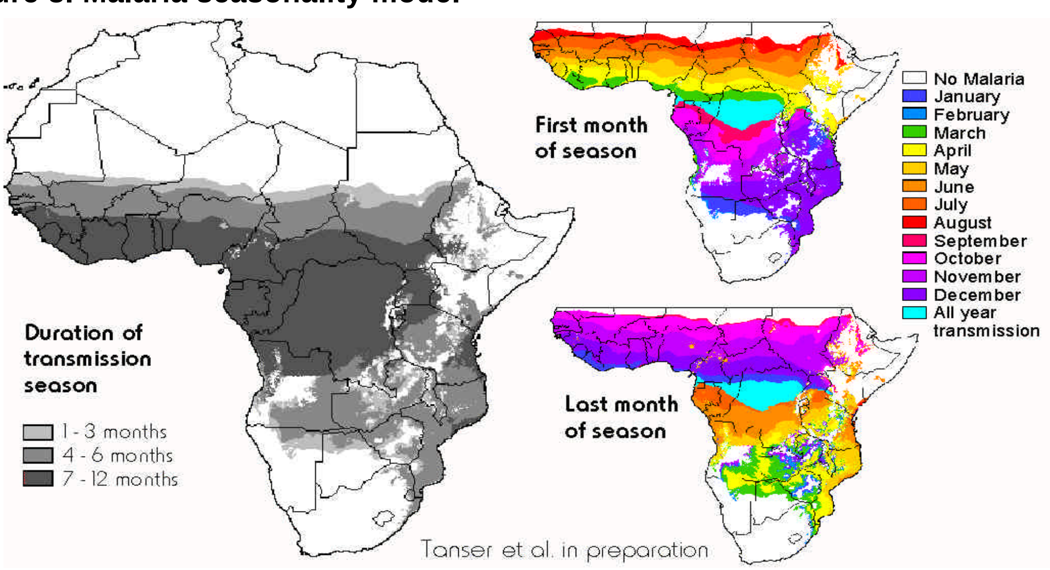
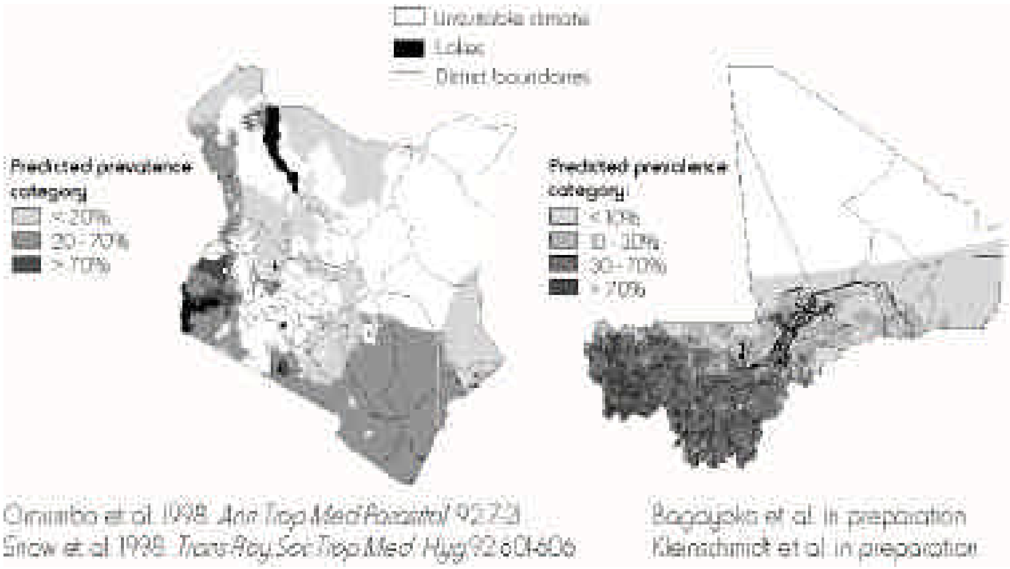


Kenya and Mali models

The regional centres have started using the empirical data at the country level to derive malaria endemicity models by statistical analysis against determining factors such as climate and the presence of water bodies (Figure 9).

Figure 9. Statistical malaria endemicity model.



Magaran Bagayoko presented the work done in this regard in Mali (10), and Judy Omumbo will give you more detail later on what has been done in Kenya (11).

Where is MARA now?

As you have seen, much data has already come in, but much still needs to be collected. Some models have been done, but they still need refining, and other models need to be developed. With the funding awarded recently by MIM, MARA has been able to continue its work.

As mentioned, the modelling of malaria endemicity, based on the empirical data, which is a major aim of MARA, has begun in two countries. The Kenya and Mali centres have broken the ground, so to speak. We are dealing with a new approach to health statistics, and several statisticians are working on the problem how to handle such unlikely, and in some ways, non-ideal data. New statistical methods may have to be developed and many methodological problems still need to be solved before we can seriously approach the rest of the continent in terms of defining endemicity.

MARA has been operating on minimal funds, and this has clearly hampered our ability to distribute initial products that have come out of the collaboration so far. Fortunately Roll Back Malaria is now sponsoring poster-map production, which will start in full swing in April, and through which all endemic countries will be supplied with poster-sized maps of those products available so far.

Where is MARA going?

Obviously, we are working towards our ultimate goal of providing an atlas of malaria risk in Africa, both as a book and in digital format, which will allow for future updating. We aim towards public access of collected malaria data and maps, in the form of posters as well as via the Internet. Along this road towards an atlas, we have published the first technical report, which you have all received, which covers the work done to date and we would appreciate your comments and opinions by filling in the questionnaire included.

MARA has come a long way since its beginnings. The regional data collection centres are slowly being joined by country centres, where individuals buy into the aims and goals of MARA and take on the MARA related activities and data collection within their own countries. This is a great development, since finding hidden data sources in your own country is always easier than in someone else's. But more than that, this increasing involvement of dedicated individuals at country level is strengthening the network, building up local GIS capacity and increases the long-term survival chances of MARA, which is important if the repository of data is to be kept up-to-date.

Another important development is that as MARA is gaining more momentum, the web of contacts and partnerships continues to grow. As a result of this, different interest groups are starting to crystallize, focussing on more specific aspects that have emerged over time. So there are groups focussing specifically on modelling and statistics, vector distribution and entomological data, drug and insecticide resistance, the use of satellite imagery, and so on.

The data collected and the work being done by MARA has incredible potential to support control activities in countries, and Judy Omumbo will now give you some insight by giving you the example of work done as part of the MARA project in Kenya.

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The MARA/ARMA Collaboration and Health Information Systems for Malaria Control: An example from Kenya

Judy Omumbo, Kenya Medical Research Institute/Wellcome Trust Collaborative Programme Programme, Nairobi, Kenya

Summary

Good information systems are vital to the success of malaria control programmes in Africa. Although different groups involved in malaria control in Kenya routinely collect many data on malaria there are gaps in information transfer between the research and the malaria control communities. One way of bridging this gap is to facilitate inputs by both parties at each stage of the information development process and to provide research results in a format that is clear and relevant. This paper presents the beginnings of the development of a Geographic Information System based Malaria Information System initiated and developed by malaria researchers and the National Malaria Control Programme in Kenya.

Background

Compared with other diseases, relatively little empirical information is readily available to malaria control workers in Africa for defining and evaluating the impact of disease. Studies of malaria in 5 areas of differing epidemiology across Africa show that the clinical spectrum and age profile of severe disease are related to intensity of transmission[1]. The effectiveness of different control interventions is likely to be related to the level of endemicity[2, 3]. A geographical description of endemicity such as is provided by a map is therefore an essential tool for both epidemiologists and control planners to use as a basis for decision making on appropriate interventions and resource allocation.

Malaria researchers in Africa have recognised the need for a comprehensive malaria atlas and the MARA / ARMA Mapping Malaria Risk in Africa (MARA) international collaboration was set up in 1996 with a view to addressing this need[4]. The past decade has seen accelerated developments in the field of Geographic Information Systems (GIS) which involve computerised desktop mapping and relational databases. This paper looks at the ways in which MARA has used GIS to develop tools for malaria information management in Kenya. A key objective of MARA is to make data available to national malaria control teams in order to promote information-driven approaches to malaria control. To this end, MARA has operated in Kenya at three levels. The first has been the development of a malaria risk stratification model. Secondly, this model has been used to identify populations at risk of different epidemiological scenarios of malaria and thirdly the information has been fed into the National Malaria Control programme where one of the results has been the setting up of a Malaria Information System.

Materials and methods

i. Empirical data sources:

Since 1996 a comprehensive search for all published and non-published malaria prevalence data from cross-sectional surveys of children less than 10 years old has been conducted in Kenya[5]. Searches of journals, Ministry of Health records, books, postgraduate theses and research reports identified over 800 studies dating from 1929 to 1997.

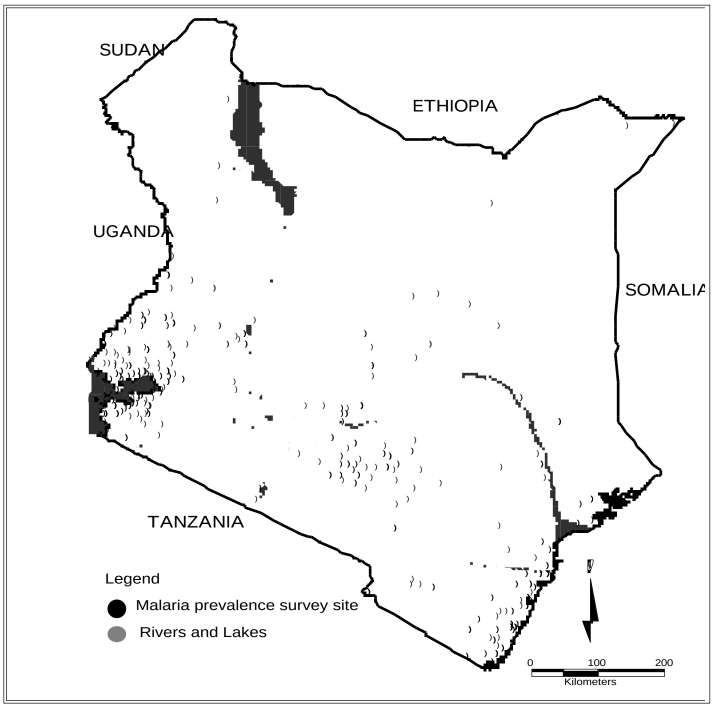


Figure 1: Locations with cross-sectional parasite ratio data[5].

Each survey was geographically referenced and mapped using the GIS software MapInfo[6] (Figure 1). Since the parasite ratio (PR) data collected are derived from surveys conducted over a long period of time, an assessment of the stability of this endemicity marker over time and across different age groups was conducted. This assessment showed that the measure remained relatively stable over time, place and age classes within the broad definitions of high, moderate and low transmission intensity.

ii. Classification of endemicity:

The development of both the malaria parasite and the vector are dependent on ambient temperature and thus climate drives the distribution of transmission[7]. This was used to define the limits of unstable and stable transmission and also the intensity of transmission within stable endemic areas. There are two settings in which unstable transmission occurs in Kenya; in North Eastern Province where transmission is limited by low rainfall and in the highlands west of the Rift Valley where low temperatures limit transmission. Stable transmission areas have been stratified using both climate and parasite ratio data from community based parasite prevalence surveys conducted in Kenya since1960. Areas of high stable risk have been defined as those where the PRs in childhood are Δ 70%, low stable transmission areas are where PRs are less than 20% and moderate transmission areas have PRs of between 20 and 69%. 124 community based parasite ratio surveys of children aged 0-10 years were selected from the larger data set for use in the model. Linear discriminant analysis was then used to stratify geographical areas of stable malaria endemicity according to low, moderate or high levels of risk based upon climatic suitability for transmission. The model was able to correctly classify 75% of the empirical PR data[8].

Results

i. A model of malaria endemicity:

The resulting transmission intensity map shows that Kenya experiences the whole range of malaria epidemiological conditions across the country[8] (Figure 2). Highest transmission intensities are experienced along the Indian Ocean coastline at Kwale in the south east of the country and around Lake Victoria in western Kenya while large areas of the country lie within unstable or low, stable endemic conditions.

ii. Stratification of populations at risk

The next step involved apply the risk map to population distribution to determine who is at risk from what level of malaria[9]. Population data for each sublocation were obtained from the 1989 national Population Census and projected to 1997[10]. Using the GIS , the total number of persons per fourth level administrative unit (location) living within each stratum of endemicity was determined (Figure 3).

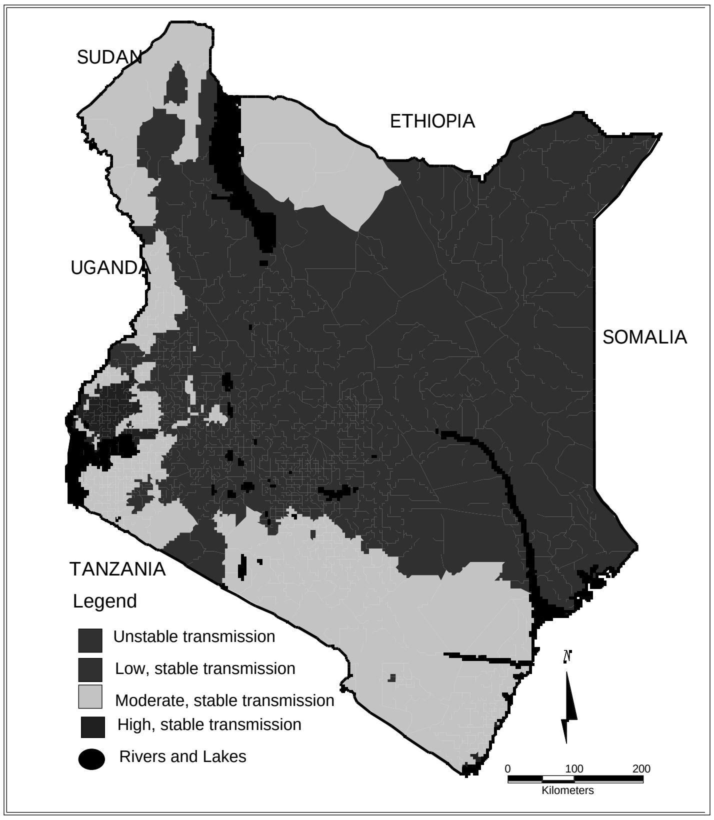
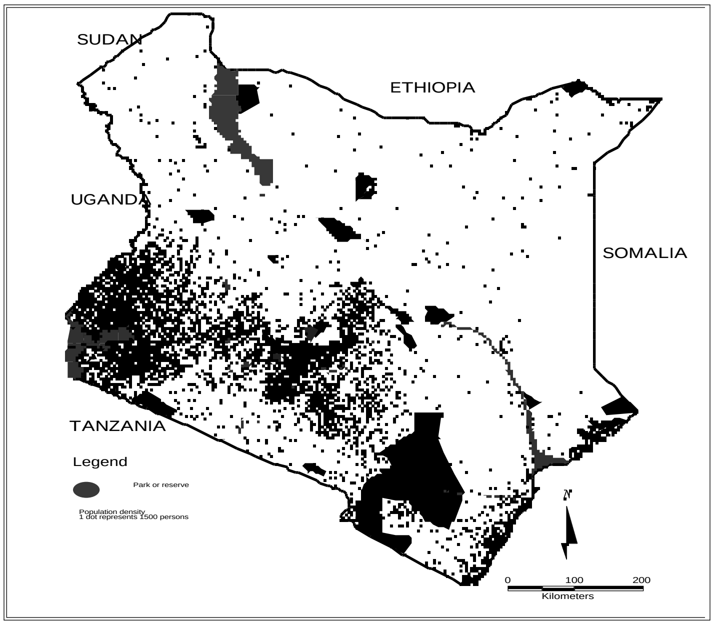


Figure 2: Malaria endemicity model.

Figure 3: Population distribution (1989 national census estimates projected to 1997)



Roughly half of Kenya's population live in areas of moderate to high stable malaria transmission whilst the remainder live under conditions of either low parasite exposure or unstable conditions (Table 1).

Malaria endemicity classification	Percentage
High Stable	13
Moderate stable	40
Low Stable	17
Unstable	30
Total	100

Table 1: Distribution of populations at risk by malaria endemicity classification.

iii. Estimation of malaria mortality risk:

Malaria mortality rates have been estimated under different scenarios of endemicity in Africa[9]. These rates have been applied to population groups to produce estimates of malaria's disease burden as it affects Kenya (Table 2). Approximately 26,000 children under the age of 5 years die of malaria yearly. This translates to 72 childhood malaria deaths in the country each day. Within rainfall limiting unstable areas, malaria mortality is estimated as zero but this may rise to between 3,000 and 14,000 deaths during an epidemic. Estimates for disease burden during pregnancy are only available for moderate to high stable endemic areas. Based upon these data, approximately 6000 women living in these areas will suffer an episode of severe malaria anaemia each year.

	Temperature limiting unstable malaria and low stable endemicity	Moderate stable endemicity	High stable endemicity
Numbers of deaths among 0-4 year olds per annum	**1,223**	**18,293**	**6,614**
Numbers of severe anaemia events among Primigravidae per annum	**N/A**	**4,311**	**1,567**

Table 2: Estimates of malaria mortality by risk group and endemicity class[9].

iv. Links with the National Malaria Control Programme:

A key aspect of the success of malaria control is the establishment of links between research groups and control specialists. Collaboration has been established with the National Malaria Control Programme and through this we shall be able to further define populations at risk, to look at drug requirements and the spread of resistance, and to rationalise control activities in the country. By way of example the distribution of Insecticide Treated Bed Net (ITBN) activities in the country has been examined[11]. A questionnaire-based study was conducted to quantify the groups and populations involved in Community Based Health Care (CBHC) activities and those that carry out ITBN related activities identified. Each Non-governmental organisation, research group, mission, Ministry of Health or other health provider was asked to list the areas where their activities are targeted. The sites were then mapped using GIS. The resultant map shows how bed net programmes are concentrated in areas of low risk, which are also sparsely populated as opposed to the densely populated high and moderate transmission areas of Western and Coastal Kenya (Figure 5).

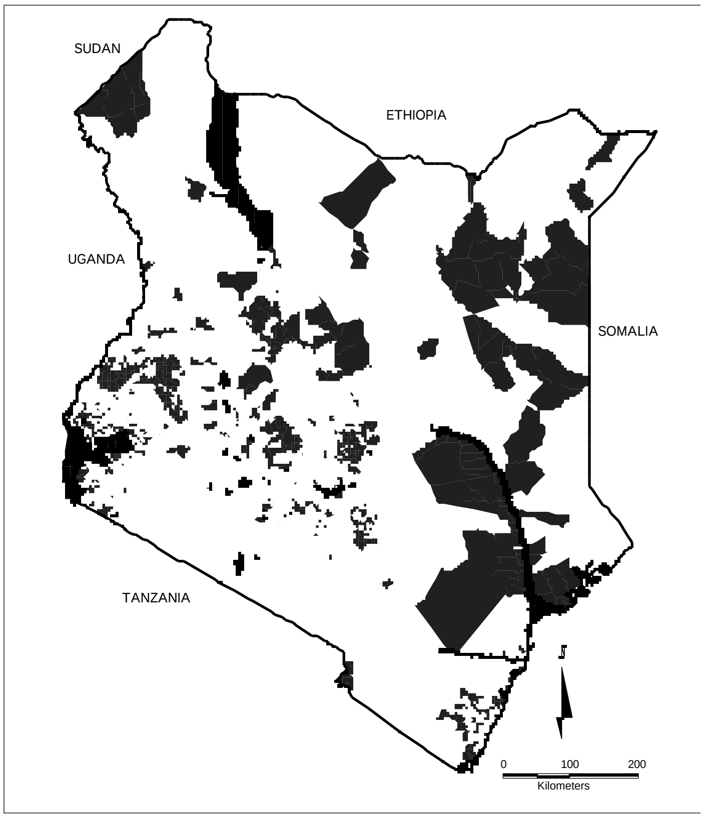


Figure 4: Target populations for Insecticide Treated Bed Nets or intervention study sites (gray)

Good information systems are vital for the success of healthcare programmes and it is hoped that these beginnings will provide a platform for more information-driven control programmes in Kenya in the future.

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BREAKOUT SESSIONS: HEALTH INFORMATION SERVICES

Programme

1. Data Needs for Malaria Control I.

Chair: Dr. Christian Lengeler

Rapporteur: Ms Marlies Craig

Presentations (15 minutes each)

1. National Health Statistics – quality and use - Penny Philips-Howard
2. Linking demographic surveillance to health service needs – The TEHIP/AMMP experience in Tanzania - Don de Savigny
3. Computer assisted health information systems for malaria control - Brian Sharp
4. GIS for malaria mapping in Mali. - Magaran Bagayoko
   Discussion (45 minutes)

2. Data Needs for Malaria Control II.

Chair: Dr. Don de Savigny

Rapporteurs: Dr. Pierre Ngom, Dr. Penny Philips-Howard

Presentations (15 minutes each)

1. Population surveillance to measure mortality – the INDEPTH network - Ricardo Thompson
2. The potential role of government mortality statistics in the evaluation of the efficacy of ITBN - John Arudo.
3. Health service surrogate markers for monitoring drug resistance and the EANMAT network - Theonest K. Mutabingwa
4. Measuring quality of clinical care – the IMCI experience - Doyin Oluwole
   Discussion (60 minutes)

3. Epidemic Preparedness and Data Needs.

Chair: Dr. Charles Delacollette

Rapporteurs: Dr. Charles Ravaonjonahary, Mr. Steve Connor

Presentations (15 minutes each)

1. The highland malaria project - Jon Cox
2. Climate and malaria forecasting - Mark Jury and Macol Stewart
3. Preparing for malaria epidemics in Namibia - Richard Kamwi
4. Highland malaria in Uganda: Epidemic transmission at low vector densities - Kim Lindblade.
5. Control of epidemic malaria on the highlands of Madagascar - Franco de Giorgi.
6. The relationship of malaria outbreaks to preceding meteorological conditions in Zimbabwe - Washington Zhakata
   Discussion 30 minutes

Summary Report: Health Information Services

Introduction

Through the brokering of new partnerships at the international and national levels, RBM has created a new era for malaria control in Africa. To retain credibility within the eyes of the donor community and the population of Africa who continue to suffer from the growing adverse consequences of malaria infection, precise information is required on the current distribution and magnitude of the disease burden; demonstration of appropriate allocation of wider health sector funds in accordance with the burden; and ultimately that the optimistic hopes that reducing the burden by 50% by the year 2010 has been attained.

Reliable health Information provides the power to define needs, identify problems, effect change and monitor impact. Information necessary for malaria control operates at various levels:

- Credible information on the burden of malaria and its impact upon the social, economic and demographic structure of country. Such "advocacy" information is paramount to solicit appropriate action by national governments and international donor commitment.

- District-level information on disease burdens, clinical and seasonal patterns and spatial distribution allow appropriate and targeted allocation of limited resources within financially constrained environments to achieve maximum return on investment in health.

- Information on use and quality of allocated services for malaria control and prevention by target populations allow programmes to be constantly monitored, feeding back into revised action and financial plans.

- The measurement of the health-impact of targeted malaria services provides district, national, regional and international health professionals in definition of their return on investment.

Summary of Presentations

- New and old approaches to measuring disease burdens and risks [1]:

There exists a wide and varied source of health information systems that operate within the African region which could be used within the context of malaria control. Demonstrations that traditional Health & Management Information Systems (HMIS) provide inequitable distribution of district-level health resources in Tanzania highlighted the need to revisit their future value for RBM within the framework of health sector reform (De Savigny). Regional differences may exist in the completeness and coverage of information obtained from national HMIS or civil registration systems. In Western Kenya seasonal patterns of mortality were consistent between detailed population surveillance estimates and those derived from the local registrar of births and deaths (Arudo), HMIS data may be a valuable resource for local management of resources, definitions of local malaria epidemiological patterns (Philips Howard) and monitoring secular trends in disease for surrogate markers of drug resistance (Mutabingwa) or epidemic predictions under conditions of unstable

[1] See also plenary presentation by Don de Savigny

malaria (Lindblade, Zhakata, Kamwi). Specialised uses of HMIS data may provide reliable markers of seasonal disease patterns and relative impacts of targeted community-based interventions (e.g. ITBN) (PhilipsHoward). However there was a clear demonstration that the precise nature of the malaria burden at the household level was not captured through facility-based surveillance systems.

To obtain reliable estimates of disease burden at the household-level demands intensive, longitudinal household demographic surveillance (DSS). Such systems have, in recent years, been established in three districts of Tanzania and their output has been used to redistribute health resources by District Health Management Teams (DeSavigny). DSS sites in Africa were first established in Senegal during the 1960's. During the mid-to-late 1980's there has been a proliferation of DSS sites created by epidemiologists and demographers to understand the epidemiological basis of mortality and to test the impact on mortality of new interventions through individually or community-randomised controlled trials. DSS sites are characterized by household censuses, monitoring of vital events (births, deaths and migrations) and examinations of causal factors of mortality and the circumstances (including treatment-seeking behaviors) surrounding each event. Whilst infant and childhood mortality remains unacceptably high in much of sub-Saharan Africa deaths are comparatively rare events and DSS surveys require large populations. In response to the diverse nature of the casual structure and epidemiological basis of mortality in Africa and the need to pool resources and information, a network has been created to link DSS sites across Africa - INDEPTH (Thompson). This network currently involves 23 sites in Africa with approximately 1 million people under surveillance. It is envisaged that this network will provide a powerful resource for monitoring the long-term impact of initiatives created through the RBM movement and that the numbers of sites and population under surveillance will continue to grow (Thompson).

- Monitoring & evaluation

Monitoring and evaluation is critical for guiding disease control programmes. Several examples of M&E were provided during the presentations including those developed to support IMCI (Oluwole) and a regional network to monitor drug resistance in East Africa, known as EANMAT (Mutabingwa). These specialised surveys provide additional "process" and impact information not achieved through routine health statistics or demographic surveillance. Monitoring the quality of clinical care and the efficacy of anti-malarial drugs enables programme managers to re-orientate existing strategies to meet newly defined weaknesses and needs.

- New technologies [2]

Information technology and globally available data sources have provided new opportunities for health information specialists and epidemiologists working in malaria research and control. In South Africa the close collaboration between the research and control communities has enabled the transfer of new technology to improve the quality, processing speed and use of malaria information through the establishment of a computerized system of direct case-data entry at the peripheral levels of the health service (Sharp). This system has engendered increased value in the information generated by those who record the data. Mapping malaria risk has a long tradition in Africa, however, the advent of new computer tools, Geographic Information Systems, have provided a more powerful means of capturing, storing and displaying spatial malaria information. In Mali,

[2] See also plenary by Marlies Craig and Judy Omumbo

these new tools have been combined with statistical approaches to define high resolution endemicity risk maps providing malaria control programme managers with a visual image of the country's high, moderate and low intensity transmission risk areas (Bagayoko).

- Epidemic preparedness and data needs

Whilst unstable transmission areas constitute a low morbid and fatal risk to the population on an average year, these areas are characterised by large scale inter-annual variations in risk leading to high disease burdens amongst the entire population. Unstable areas of malaria transmission in Africa present a special need for monitoring systems including the geographic location of these at-risk communities, monitoring changes in disease risk and the predictive value of the climatic determinants of inter-annual variations in disease risk.

The Highland Malaria Project (HIMAL), a component part of the MARA Mapping Malaria Risk in Africa initiative, has initiated a detailed search and analysis of the African literature related to malaria epidemics. These data were combined with climatic and topographical data within a GIS platform to provide new insights into the limits of epidemic prone areas of East Africa (Cox). HIMAL's new research agenda will focus on further detailed analysis of other risk factors (including land use, drug resistance and population movements) through prospective studies across the international borders of Tanzania, Uganda and Kenya.

Forecasting epidemics has always been difficult, not least because long-term data series are often not available. A model has been investigated using the relationships between rainfall and temperature proxies and epidemiological records from eastern South Africa over a 35-year period (Jury & Stewart). The system allows for a lead-time of 5-6 months and has been operational for the past 4 seasons with a 'success rate' of 75%. The constraints and use of available epidemiological surveillance tools were also provided by control programme managers from Namibia (Kamwi) and Madagascar (Ranavio), highlighting the practical applications of disease and climate monitoring in these areas of Africa. In a highland community of Uganda, East Africa, detailed epidemiological investigations were undertaken during at epidemic experienced at the beginning of 1998 demonstrating the health consequences of low intensity transmission upon all age groups (Lindblade). Whilst climate drives the likelihood of epidemic risk in Southern Africa (Jury & Stewart; Kamwi; Zhakata) in East Africa the risks of epidemics may involve more complex and wider series of parameters (Cox, Lindblade).

Breakout discussions

The participants from the control community articulated the issues associated with maintaining HMIA in their respective countries (Rwanda, Namibia, Zambia, Botswana, Zimbabwe and Ghana).

There was a much greater familiarity with HMIS than DSS by control programme staff. In addition there was a comparative difference in the apparent use of HMIS data between Southern Africa and the rest of sub-Saharan Africa, among the former countries there was a perceived value in the HMIS system for monitoring malaria control programmes. Nevertheless a consensus view was expressed over the innate problems associated with HMIS including motivation of staff, understanding of why data was being collected, unwieldy and multiple data forms, poor feedback, lack of appropriate training in data analysis and uncertainty in completeness of information. The latter was perceived as particular problem in areas where poly-pharmacy was a common leading to many disease events would being missed at the formal health service point.

The precise translation of information into action and decision making was well articulated for IMCI (Oluwole) and resource allocation in Tanzania (De Savigny) but concerns were raised on how information generated at health facilities and through GIS could actually be used by health planners.

The costs of DSS were discussed in the light of those under surveillance versus the use of sentinel DSS to provide nationally representative estimates of disease burden where the latter represents only 0.03 US$ per capita. It was suggested that indirect demographic techniques, such as the preceding birth technique and Brass's Children-Ever-Born method, be tested against direct demographic surveillance with a view to reducing costs. No one had any comparable costs for HMIS in Africa however it was highlighted that sentinel approaches to HMIS disease surveillance were currently being developed by WHO in Africa.

Overall it was clear but information needs to be tailored in accordance with epidemiological and demographic circumstances. Urban and rural differences in health service utilization may lead to biases in routine HMIS data and active case-detection of infection rather than passive detection of disease should reflect the stability of transmission and immune status of the population.

In summary, the development of information systems should start with the definition of objectives, what type of interventions are required, and then define indicators, and which methods are most appropriate to capture the relevant data. Participants stressed the relevance of assessing the utilization of HMIS - since discussions seemed to polarize between DSS where high quality data which could be generated currently only in a few places, against the generation of masses of data through HMIS which is mostly of low quality. The importance of data collection methods which reach the homes was stressed since a high proportion of child mortality and morbidity occurs within the community. Finally the participants agreed on the importance of avoiding data overload, so that a critical minimum dataset was essential and that research was essential to define the most sensitive indicators.

Possible research agenda to address needs for health information to support malaria control in Africa.

Facilitators worked with the commentary provided by the control community during the breakout discussions to formulate a series of possible research questions to provide operationally relevant answers to better guide information systems for malaria control. This tentative agenda was then presented to the group for discussion, refinement and addition. The resultant list was as follows:

1. **Formative research** on the value and utilization of existing HMIS, National Demographic & Health Survey (DHS) and civil registration data at all levels of the health sector- who uses the data, for what, how long dose it take to collect, collate and forward, extent of district or national level feedback to data collectors, what is the value of the data (including tangible demonstrations of the use of the data for planning or managing malaria or disease control or prevention) etc.

2. **Qualitative comparisons** between traditional civil registration, HMIS, DHS (involving indirect demographic techniques) and DSS systems to establish coverage, accuracy and characteristics of missed mortality events.

3. Analysis of the **comparative costs** per capita of various surveillance systems aimed at measuring community-based mortality allowing for sensitivity and specificity of coverage.

4. Development of **new tools** for capturing information relevant to characteristics of district-level malaria control and prevention plans of action. The characteristics of these tools to depend upon the ecological and epidemiological characteristics of districts (e.g. epidemic versus stable transmission). Possible areas to explore would be the use of services during terminal disease events, quality of clinical care through exit interviews, use of blood transfusions as a surrogate marker of anti-malarial drug resistance, etc.

5. Development of **new analytical tools** which will assist planners at national, district, local levels to interpret and act on relevant health data.

6. Studies to examine ways in which HMIS can define health impacts of programmes aimed at malaria prevention.

7. For epidemic preparedness it was suggested that the outcomes should be a guideline on forecasting, early detection and control of malaria epidemic in Africa. To achieve this research is needed in the following areas:
   a. Which indicators to use in early detection.
   b. Forecasting tools producing simple summary indicators for use at district level. These should be developed outside the health sector by climate meteorological forecasters/food security and drought monitoring systems and made available to public health services.
   c. The development inter-country / country preparedness plans of action including forecasting / early detection instruments and adequate ready to use at any time control options where these do not exist.

Links between research and control

The group recognized that discussions were of a generic nature and not specific to malaria. This is particularly significant when developing partnerships between research and control communities. In the case of HIS a wide series of stakeholders must be consulted because research to practice will depend upon ownership by the entire health sector. For the purposes of demographic, epidemiological and health service surveillance malaria researchers and malaria control specialists must consult a much wider research and health service community. In several Southern African countries such intersectorial collaboration may be less relevant given that information systems for malaria control are run specifically by the malaria control programmes.

In order to insert and validate sometimes quite sophisticated new tools in the field of epidemic forecasting, it will be beneficial to improve collaboration between meteorologists and district medical officers / malariologists in selected provinces/districts prone for malaria epidemic. Furthermore, countries which have sophisticated and developed epidemic preparedness plans and forecasting tools should be assisted in facilitating such activities in and technologies in other regional countries with similar problems.

Capacity building

The donor community need to recognize the significance of DSS sites in Africa for the basic epidemiological understanding of the true impact of new interventions being developed within the framework of RBM. Such interventions include the role of home-based management of disease, combination therapy to reduce the evolution of drug resistance, the management of malaria in pregnancy, understanding mechanisms of natural immunity for vaccine development, determinants of epidemics to guide control and interactions between infectious and nutritional diseases and their management through IMCI to name a few. Perhaps the best examples of the power of long-term commitments of DSS are those provided by Trape and colleagues on the impact of emerging chloroquine resistance on mortality. Whether DSS will provide the best alternative to existing national HMIS systems demands further investigation, however, the value of DSS as research tools to support wider RBM decision-making is already clear. Investment is therefore required to build the continents capacity to maintain large-scale demographic surveillance systems. These commitments must have a long-term perspective - as with RBM's time-frame - changes in the health sector, new tools, drug resistance and their translation into changes in survival require 10-20 year investments.